



NASA, We have a data problem! ExMC and Bioinformatics

EVA Technology Workshop 2017

October 17, 2017

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Exploration Medical Capabilities

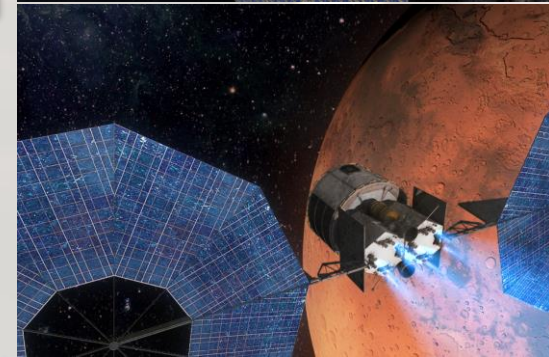
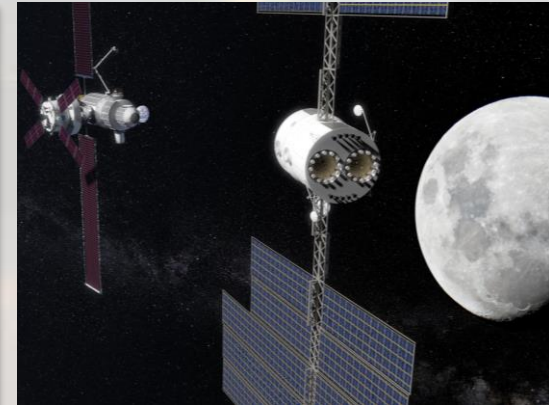
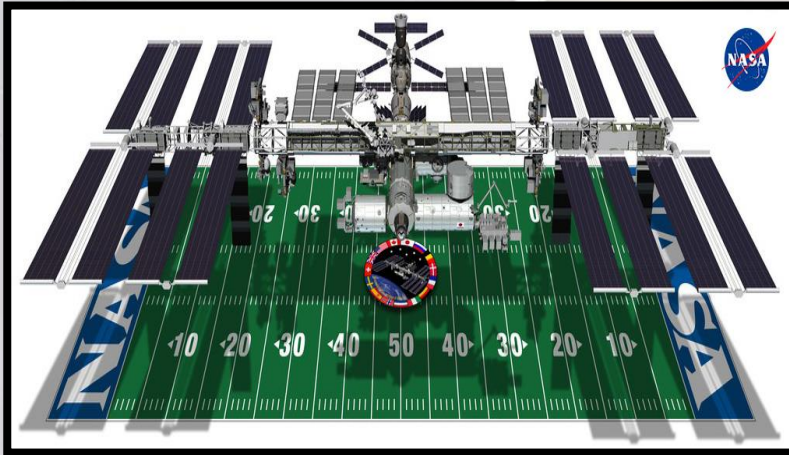
What are our mission and goals



International Space Station

Orion Capsule

Gateway Missions



ExMC – Mission

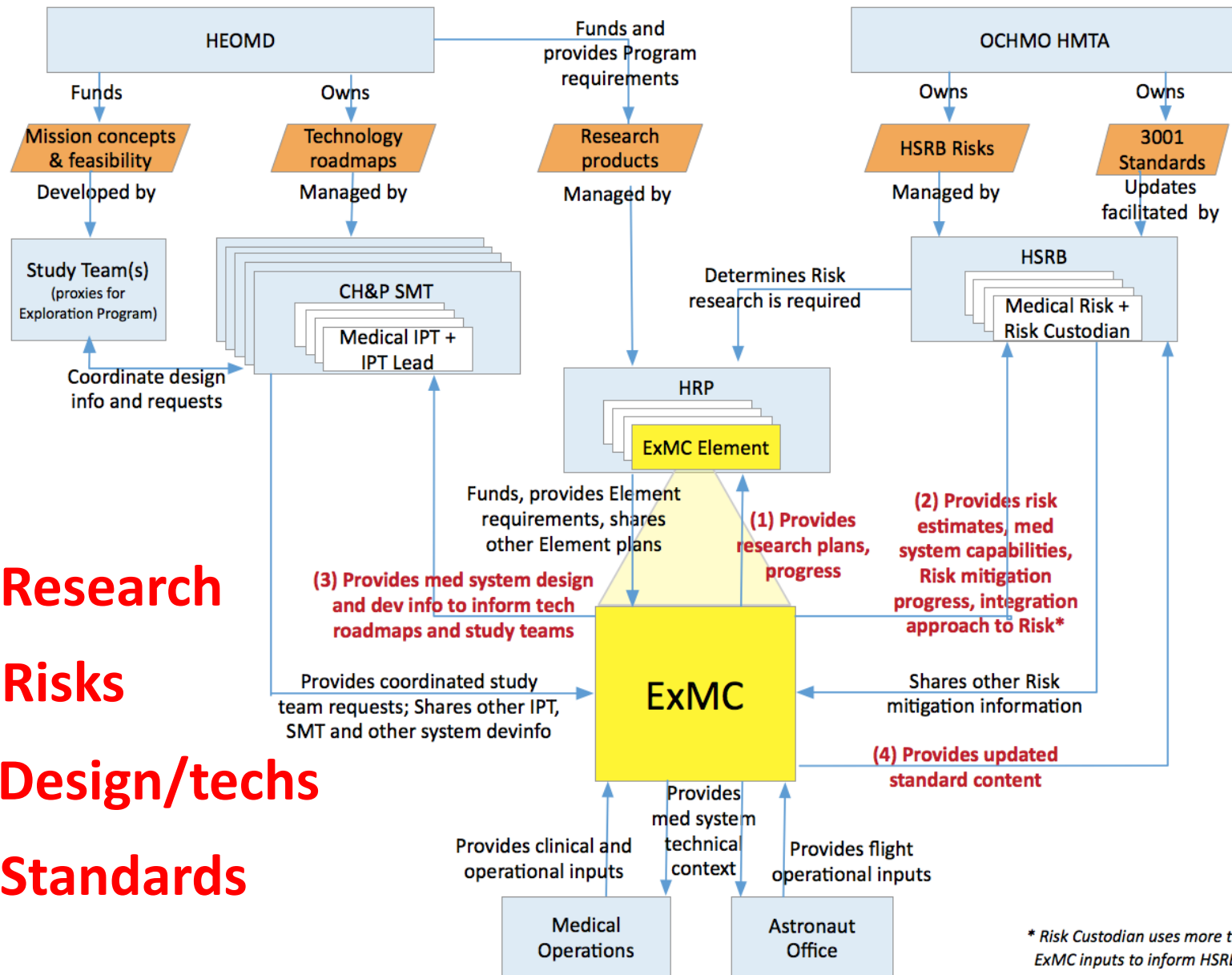


Minimize mission medical risk through medical system design and integration into overall mission and vehicle design

ExMC Team: Organizational Context



- 1) Research
- 2) Risks
- 3) Design/techs
- 4) Standards



* Risk Custodian uses more than only ExMC inputs to inform HSRB status

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[illegible]

In-Flight Activity	Description				
	Duration:	Schedule:	Flexibility:	Blood Volume:	Personnel Required:
	15 minutes	Every 2 weeks	At discretion of Crew Surgeon.	N/A	Crewmember and Behavioral Performance (BHP) Specialist
Precedents:	N/A				
Constraints / Special Requirements:	A CPC may be requested at any time by the Crew Commander, Crew surgeon (CS), Flight Director (FD), or any crewmember. CPCs shall be conducted on two-way private voice with or without video communication between each individual ISS crewmember and at a designee of the crewmember's home agency behavioral health and performance group, preferably in the crewmember's native language. Each CM to be scheduled individually, during off-duty time. Private two-way video time. N/A				
Photo / TV Requirements:	N/A				
Cold Storage Requirements:	As required				
Non-Extension Requirements:	N/A				
Leading Wake-off Requirements:	Data are crew member contacted. The crewmember is the designated recipient of the data and sharing this information is at his/her discretion. Entries will be made in the EMR for each event showing completion of the MEDB requirement and stating if any aeromedical concerns were identified.				
Data Delivery:	N/A				

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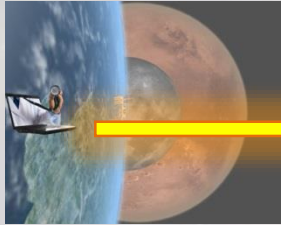


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Exploration EVA



Current ISS Ops

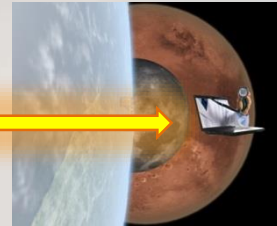


Live monitoring:
reliant on ground

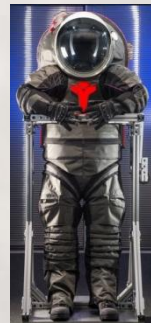


Mission tasks

Exploration



Live monitoring →
space-based expertise

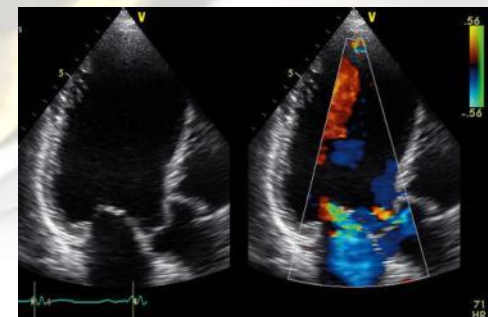
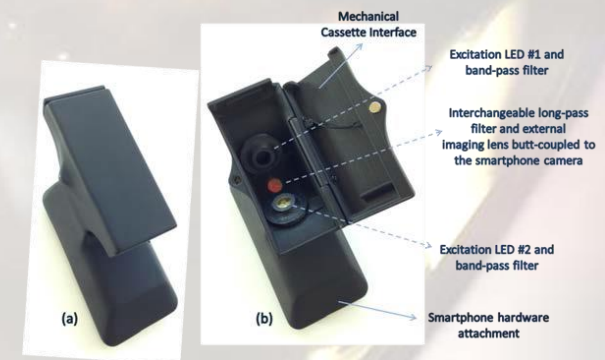
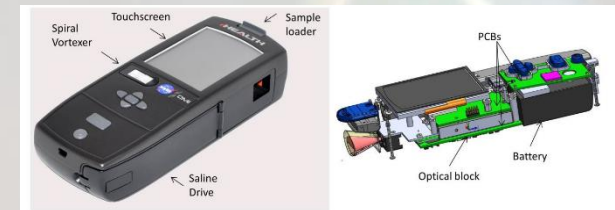


Mission tasks
Bioadvisory information
Navigation
Consumables tracking

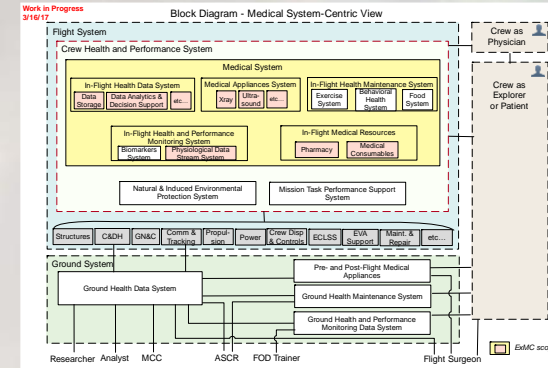
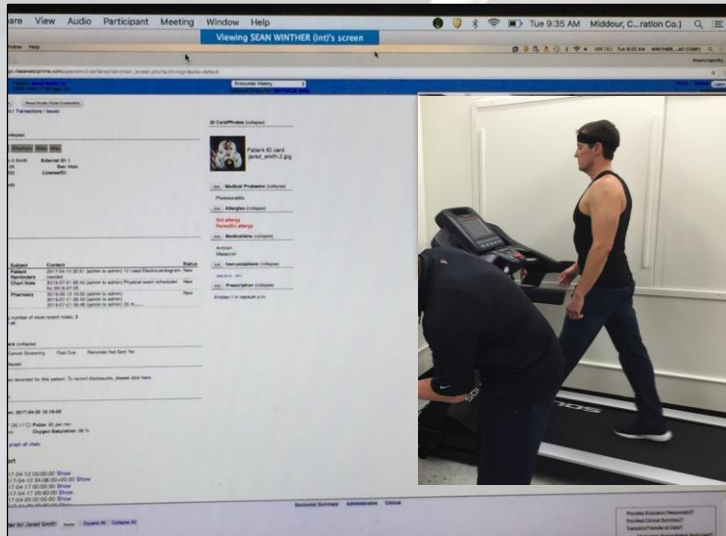
Medical Capabilities



- **Biomonitoring**
- **Radiation Monitoring**
- **Sleep Monitoring**
- **Flexible Ultrasound**
- **Pharmaceutical stability**
- **Laboratory Analysis**
- **Medical Training Platforms**
- **Medical Data Architecture**
- **Medical Systems Development**
- **Medical Risk Assessment**



Medical Data Architecture



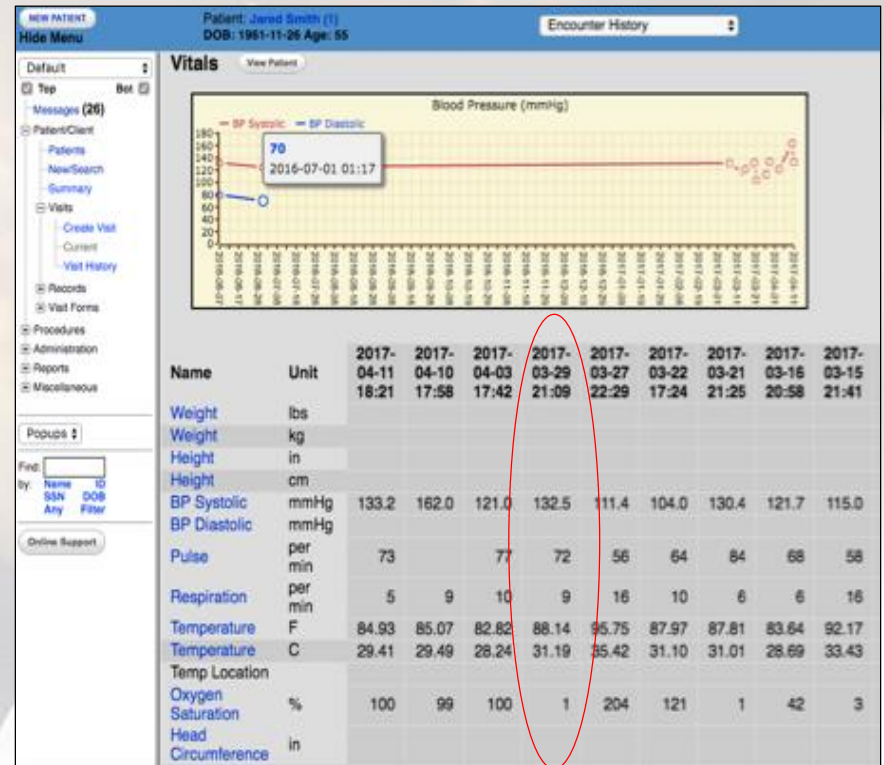
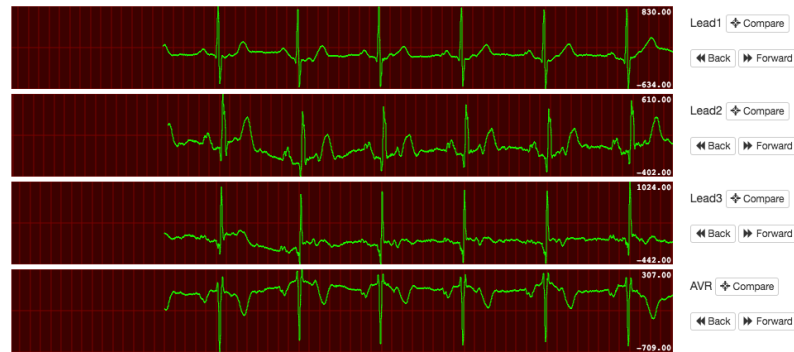
BioMetric Report

Patient Name: Smith, Jared

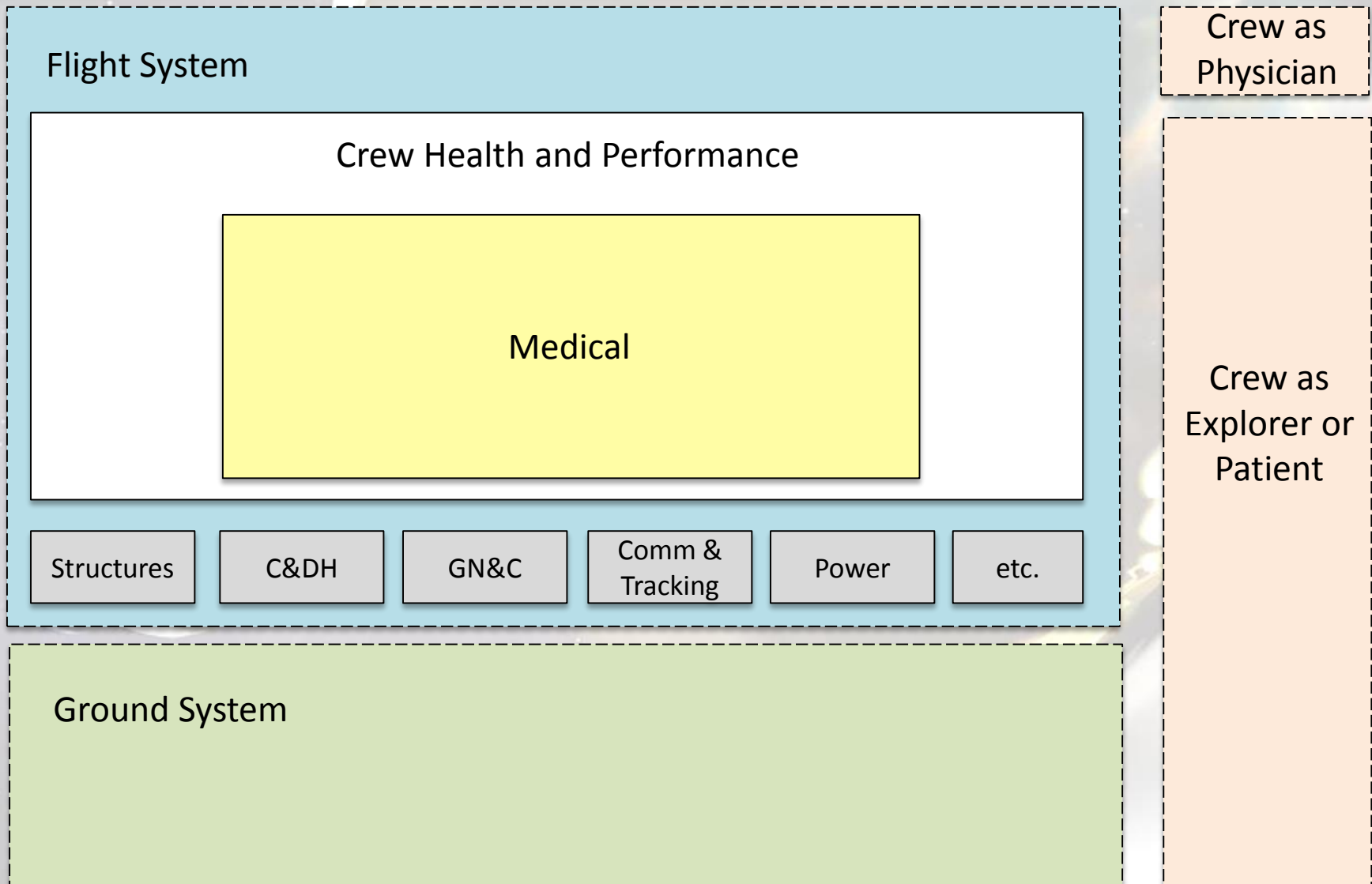
Patient Encounter Information

UTC timestamp: 2017-04-25 00:00:00

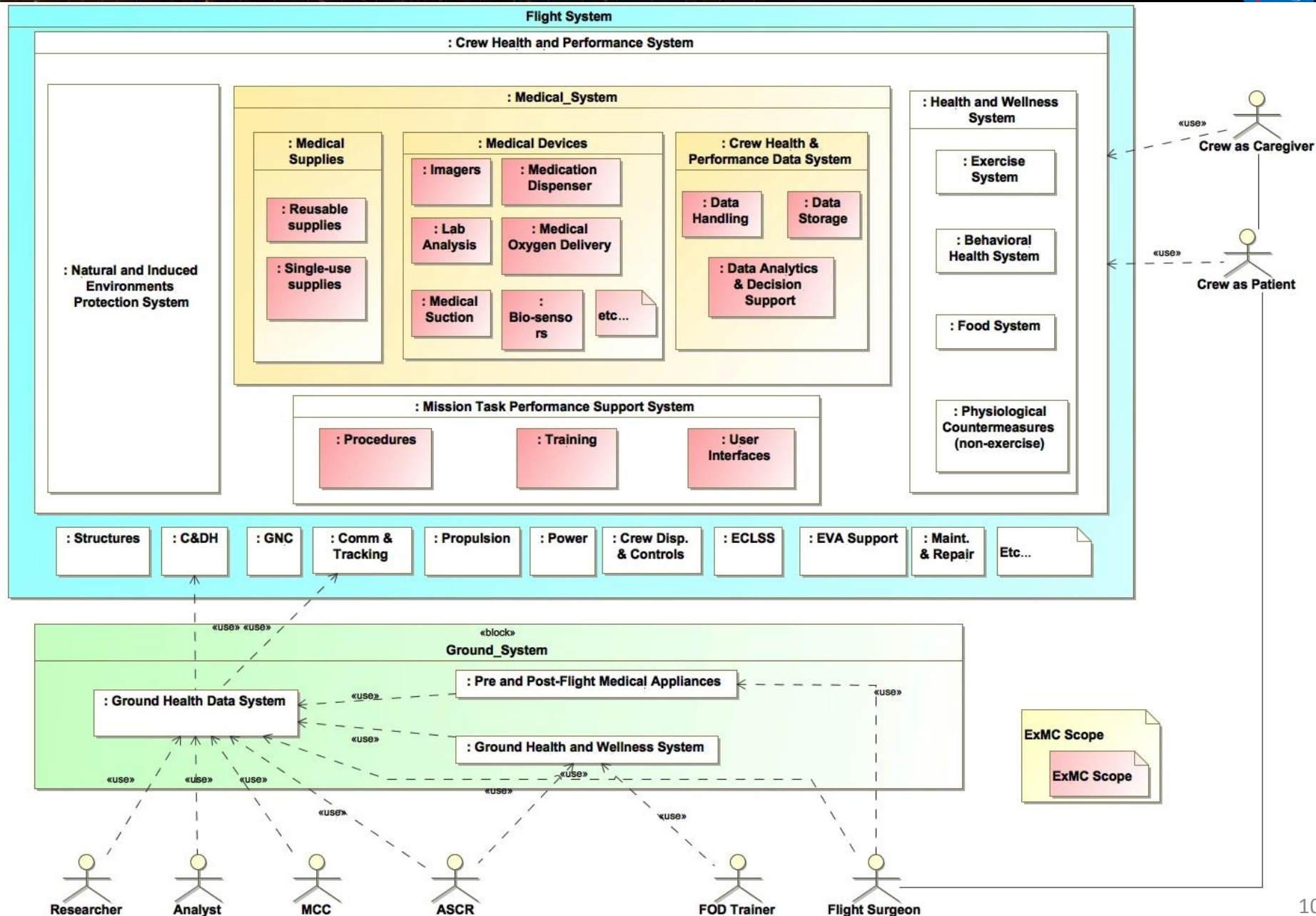
Source: CARDIAX Leads: Lead1-3, AVR



Translating to Engineering



Translating to Engineering



Development Timeline



Gateway Hab

Deep Space Transport

Mars Transit

2024

2027

2029

2033

ISS Operational Approach

Mars
Operational
Approach

**What are the
early entry
vehicle and
mission medical
integration
needs?**

- ❖ Data Architecture
- ❖ Training and Skills
- ❖ Ground Support Model Dev

- ❖ Data System Maturation
- ❖ System Integration with Vehicle
- ❖ System Testing
- ❖ Ground Support Initial Ops

- ❖ System Validation
- ❖ Ground Support Mature Ops

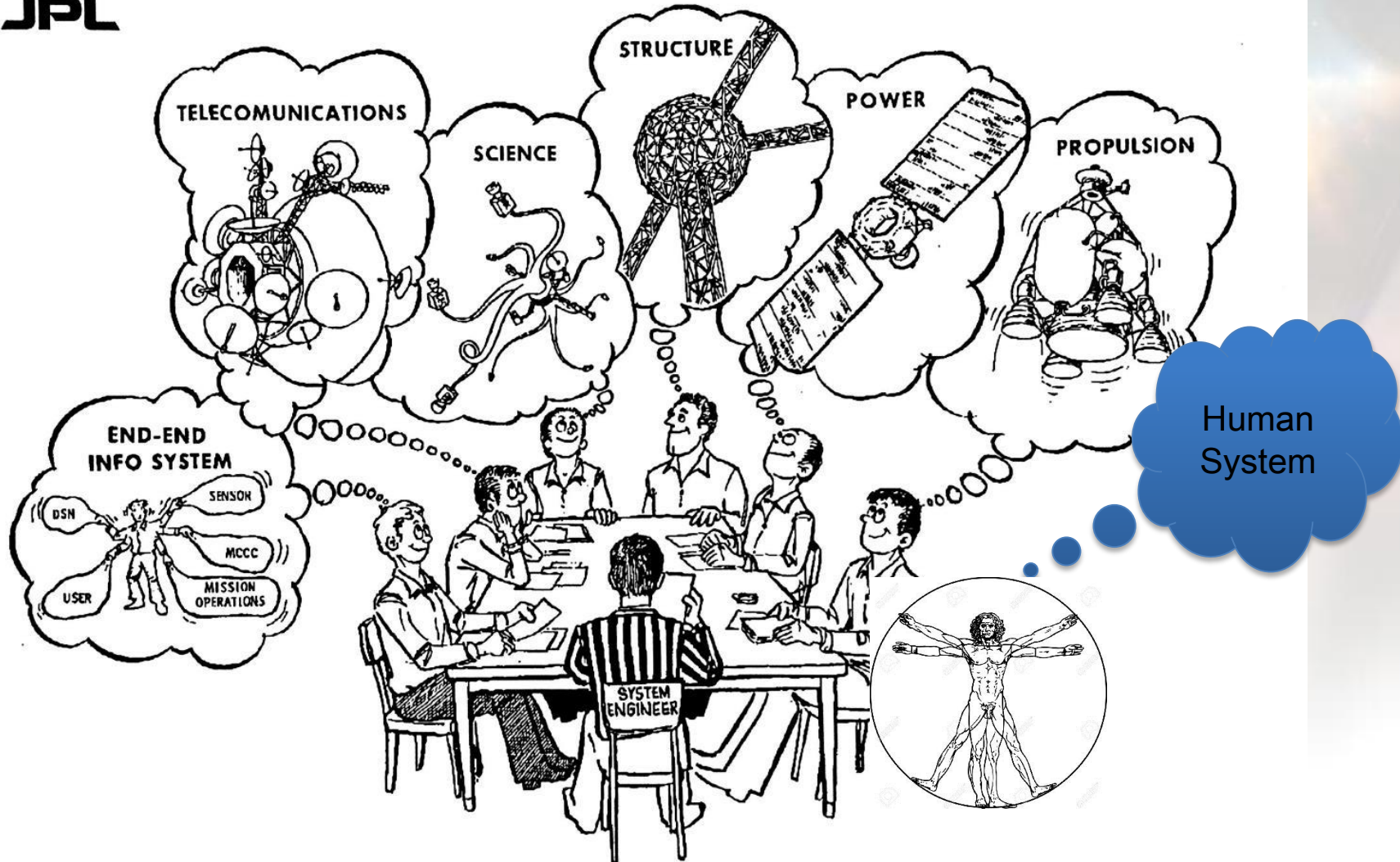
- ❖ Validated Flight System
- ❖ Validated Ground Support Ops
- ❖ Fully Integrated Human System

Human System Integration



DESIGN TEAM OPERATIONS

JPL



SYSTEM ENGINEERING AT JPL

06/14/91

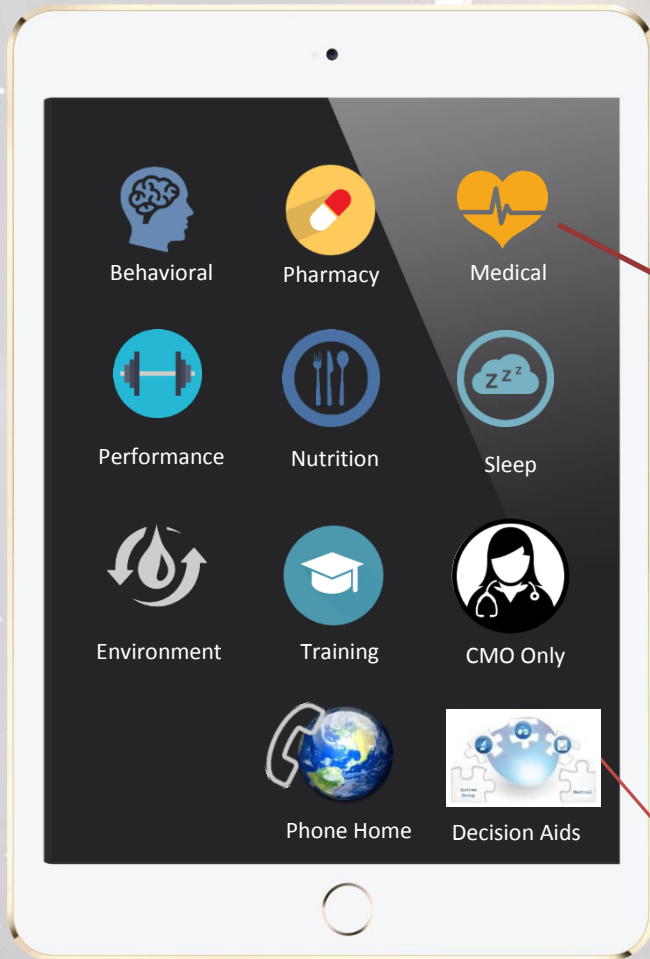
From "System Engineering at JPL" training course material, June 1991.

4.9

Moving Towards Mars: Intuitive, Usable



Notional Human System Interface



Medical

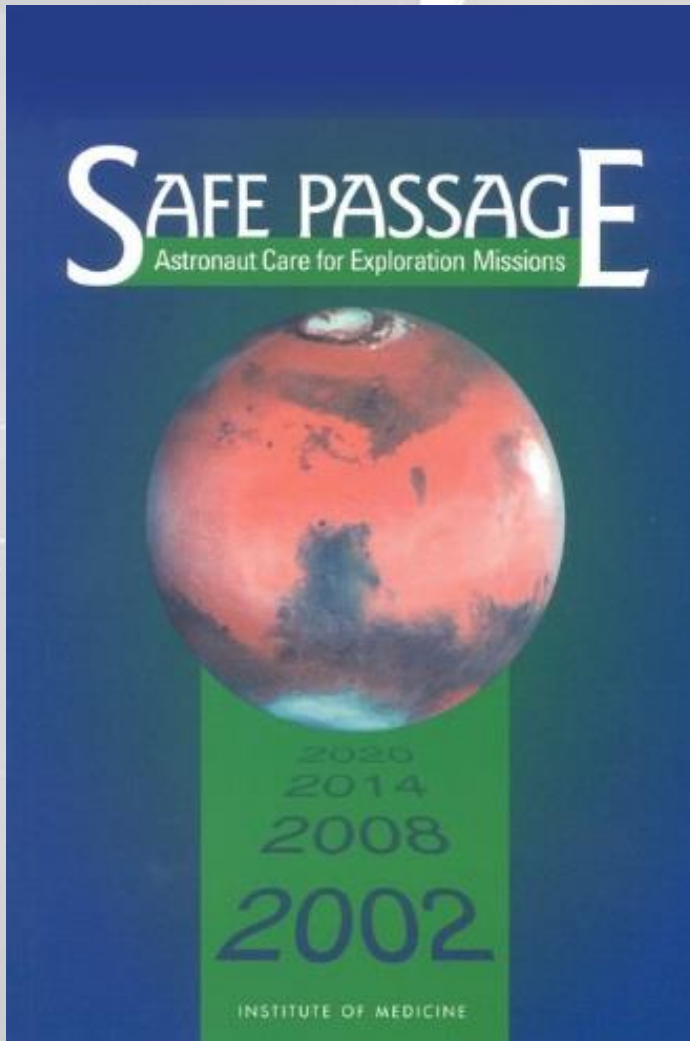
Developing Decision Aids to Enable Human Spaceflight Autonomy

Copyright © 2016, Association for the Advancement of Artificial Intelligence.

Jeremy D. Frank, Kerry McGuire, Haifa R. Moses, Jerri Stephenson



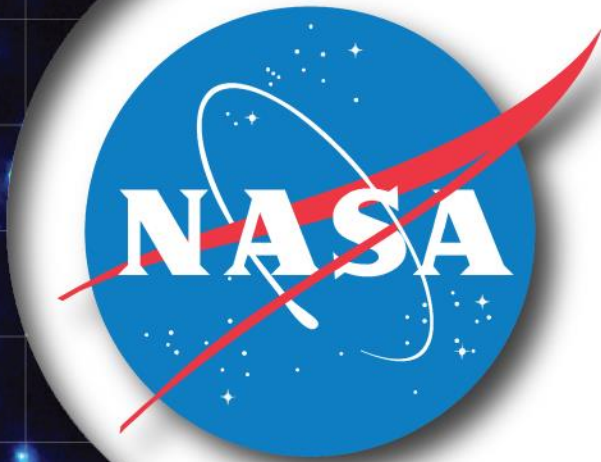
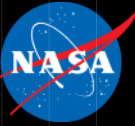
Future Direction



2001, Conclusion 6:

NASA, because of its mission and history, has tended to be an insular organization dominated by traditional engineering. Because of the engineering problems associated with early space endeavors, the historical approach to solving problems has been that of engineering. Long duration space travel will require a different approach, one requiring wider participation of those with expertise in divergent, emerging, and evolving fields. NASA has only recently begun to recognize this insufficiency and to reach out to communities, both domestic and international, to gain expertise on how to remedy it.

Committee on Creating a Vision for Space Medicine During Travel Beyond Earth Orbit, Board on Health Sciences Policy and I. O. Medicine, *Safe Passage: Astronaut Care for Exploration Missions*, Institute of Medicine of the National Academies Press, 2001.



BACK UP



ExMC – Risks



- Pharmaceutical Stability Risk
 - Renal Stone Risk
 - Acute Bone Fracture Risk
 - Celestial dust Exposure Risk
-
- Medical Risk

Select ExMC Medical Risk Gaps



Med01	We do not have a concept of operations for medical care during exploration missions.	ConOps
Med02	We do not have the capability to provide a safe and effective pharmacy for exploration missions.	Pharmacy
Med03	We do not know how we are going to apply personalized medicine to reduce health risk for a selected crew.	Personalized Medicine
Med05	We do not know how to train crew for medical decision making or to perform diagnostic and therapeutic medical procedures to enable extended mission or autonomous operations.	Training for Autonomy
Med07	We do not have the capability to comprehensively process medically-relevant information to support medical operations during exploration missions.	Real-time Comprehensive Data Processing
Med08	We do not have quantified knowledge bases and modeling to estimate medical risk incurred on exploration missions.	Databases and Modeling
Med10	We do not have the capability to provide computed medical decision support during exploration missions.	Real-time Decision Support

ExMC – Bioinformatics



Biosensor Integration Development ExMC/Canadian Space Agency Collaboration

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- ⁴Wyle Laboratories, NASA Ames Research Center, Moffett Field, CA
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- **2017 NASA Human Research Program Investigators' Workshop**

